PERSONNEL DOSIMETRY

6-1. Introduction

(1) Personnel dosimetry is a technique for detecting and measuring an individual's exposure to ionizing radiation. The Bureau of Medicine and Surgery (BUMED) requires naval activities to maintain a dosimetry program for personnel who receive occupational exposure to ionizing radiation. Personnel dosimetry is used to measure an individual's radiation exposure and to aid in minimizing exposure. Personnel dosimetry has medical, epidemiological and legal significance and must be conscientiously practiced by trained personnel under competent supervision.

6-2. Monitoring

(1) *Environmental Monitoring*. Environmental monitoring shall be performed in areas accessible to the general public to verify members of the general public are not likely to exceed a total effective dose equivalent of 100 mrem (1 mSv) per year and the dose in any unrestricted area from external sources does not exceed 2 mrem (0.02 mSv) in one hour.

(2) *Area Monitoring*. Area monitoring shall be performed in areas accessible to non-radiation workers to ensure nonradiation workers do not exceed 500 mrem (5 mSv) per year considering occupancy factors and source usage.

(3) *Personnel Monitoring*. Personnel monitoring devices shall be worn by:

(a) All adult personnel who could potentially receive from sources external to the body a dose in excess of:

Total Effective Dose Equivalent (Whole Body)	00.500 rem/yr
Shallow Dose Equivalent (Extremities)	05.000 rem/yr
Shallow Dose Equivalent (Skin)	05.000 rem/yr
Eye Dose Equivalent (Eyes)	01.500 rem/yr
Sum of deep dose equivalent and committed dose equivalent for any organ or tissue other than the lens of the eye (organ dose)	05.000 rem/yr

If the dose to the eye is expected to be less than or approximately equal to the deep dose equivalent, then whole body monitoring may be used in lieu of a special device for monitoring the eye dose. For example, in fluoroscopy a deep dose monitoring device worn at the collar to control deep dose body exposure will suffice to control the eye exposure.

(b) All personnel entering a high radiation area (i.e., an area where the exposure rate is greater than 100 mrem (1 mSv) per hour).

(c) Declared pregnant women who could potentially receive, from sources external to the body, a dose in excess of 50 mrem (0.5 mSv) to the embryo/fetus during the entire pregnancy.

(d) Minors who could potentially receive in 1 year from sources external to the body a dose in excess of 50 mrem (0.5 mSv).

(e) Radiographers and radiographers' assistants as defined in Title 10, Part 34 of the Code of Federal Regulations in addition to a self indicating and alarming dosimeter.

(f) Any other personnel deemed necessary.

(4) *Internal Monitoring*. Internal monitoring shall be performed on the following personnel:

(a) Adults whose duties are expected to exceed 10 percent of an ALI.

(b) Minors whose duties are expected to exceed a committed effective dose equivalent of 50 mrem (0.5 mSv) in 1 year.

(c) Declared pregnant women whose duties are expected to exceed a dose of 50 mrem (0.5 mSv) to the embryo/fetus from sources internal to the body during the course of the pregnancy.

6-3. Dosimetric Devices

(1) The type of dosimetric device or devices used to measure personnel exposure shall be specified by the commanding officer and approved by the Chief, BUMED. Unless other types of dosimetry are approved by Chief, BUMED, the dosimetry program shall be based on dosimetry as described in this Chapter, and its use shall be under the cognizance of the designated radiation health/radiation safety officer or senior medical representative present if no radiation health/radiation safety officer is designated. Acceptable dosimetric devices include:

(a) personnel dosimeters (DT-526 or DT-702/PD);

(b) wrist badges (DT-526 or DT-702/PD);

(c) DXTRAD finger ring dosimeter; single LiF element;

(d) pocket dosimeters, IM Series/PD; electronic dosimeter;

(e) environmental and area monitoring dosimeters (DT-526 or DT-702/PD, or DT-702/PD TLD cards in a Neutron Area Monitor (NAM));

(f) accident dosimeters, DT-518/PD and DT-526/PD (end cap); and

(g) battlefield dosimeters, DT-60/PD or DT-236/PD.

Organizations associated with the Naval Nuclear Propulsion Program will process dosimetry following the appropriate NAVSEA Radiological Controls Manual.

(2) *Personnel Dosimeters*. Personnel dosimeters are used to monitor deep and shallow dose. Personnel dosimeters are normally worn at the waist or chest. In unique situations where an individual is exposed in a high gradient field or an individual is expected to receive a partial body exposure, the monitoring device should be worn on or at the part of the body, e.g., head, neck, upper arm or thigh, expected to receive the highest exposure. Personnel dosimeters provide a very sensitive, accurate and dependable indication of the exposure to an individual. Because of their sensitivity, accuracy, and dependability, these are referred to as primary dosimetric devices. Lithium fluoride and calcium fluoride thermoluminescent materials are the sensitive elements of the three primary Navy personnel dosimeters, the DT-702/PD, and DT-526/PD respectively. Thermoluminescent dosimetry is based on the measurement of radiation using a crystalline substance sensitive to radiation that, when heated, produces light output that is proportional to the amount of radiation exposure.

(3) *Wrist Badges and/or Finger Rings* are used to monitor extremities in special situations where a relatively high local exposure is expected. For certain special situations involving high level exposures, the wearing of wrist badges or finger rings containing thermoluminescent chips to measure radiation exposure to the extremities may be required.

(4) *Pocket Dosimeters/Electronic Dosimeters*. Pocket dosimeters are self indicating devices used to monitor exposure to gamma or x-ray radiation in situations where an immediate indication of the exposure is desirable. Pocket dosimeters are pencil shaped devices containing a small ionization chamber. These devices provide very sensitive and accurate indications of the exposure of the individual, however they are susceptible to shock, dirt, moisture and other environmental factors which may produce a false over-response. Consequently, they are used as secondary dosimetry devices. An alternative to the pocket dosimeter is the electronic dosimeter which is normally battery powered, has a digital display of integrated dose and can be set to alarm at a preset dose or dose rate. Electronic dosimeters are used as secondary dosimetric devices.

(5) *Environmental and Area Monitoring Dosimeters*. Environmental and area monitoring dosimeters are used at the perimeter of radiation areas or in uncontrolled spaces in conjunction with occupancy factors to verify members of the general public and non-radiation workers are not exposed in excess of the limits established in Chapter 4. They should not be posted in known high radiation areas or any other

restricted area. Specific program requirements are in program radiological controls manuals.

(6) *Accident Dosimeters*. Accident dosimeters are used to monitor areas or personnel in situations where very high exposure may occur as the result of an accident. These dosimeters are less accurate than personnel dosimeters but have a much higher range.

(7) *Battlefield Dosimeters*. Battlefield dosimeters provide an estimate of personnel exposure to high levels of ionizing radiation that can be used to aid in medical triage of affected individuals. These dosimeters are less accurate than personnel dosimeters but have a much higher range.

(8) *Special Purpose Dosimetry*. Special purpose dosimetry is used to measure the exposure from unique or special sources, e.g., low energy x-rays, high energy protons, high energy heavy particles, very low or high intensity sources, etc., or to measure special radiation fields in unique or special settings. Dosimetry for special or unique situations may be obtained from the Naval Dosimetry Center.

(9) For further information or clarification, technical or administrative, concerning naval personnel dosimetry contact the Naval Dosimetry Center by telephone, letter, e-mail or message:

Telephone	Voice: (301) 295-0142/0403/6164 (DSN: 295) FAX: (301) 295-5981 (DSN: 295)
Mailing Address	Officer in Charge Naval Dosimetry Center Navy Environmental Health Center Detachment Bethesda, MD, 20889-5614
Plain Language Address	NAVENVIRHLTHCEN DET BETHESDA MD.
E-mail	help@navdoscen.med.navy.mil

6-4. Lithium Fluoride (LiF) Thermoluminescent Dosimetry

(1) *General.* Thermoluminescent dosimetry is the technique of measuring equivalent dose from ionizing radiation using a crystalline substance sensitive to radiation, that when heated, produces light output that is proportional to the amount of radiation absorbed. Ionizing radiation imparts energy to the substance and creates free electrons and hole pairs in impurities in the crystal structure. When the irradiated substance is heated in a controlled manner, the electrons de-excite and give off energy in the form of visible light. The total amount of light is proportional to the energy absorbed from the ionizing radiation.

(2) Lithium Fluoride Dosimeters. The lithium fluoride thermoluminescent dosimeter, referred to as the LiF TLD, is capable of detecting beta, gamma, x-ray, and neutron radiation. LiF is extremely sensitive to low level radiation exposure, including background radiation.

6-5. DT-702/PD Dosimetry

(1) *General.* The DT-702/PD LiF thermoluminescent dosimeter is designed to detect beta, gamma, x-ray and neutron radiation. This system has four LiF TLD chips on a card and is used with a black badge holder. The following paragraphs describe the use of the DT-702/PD for monitoring personnel and areas for ionizing radiation. The DT-702/PD is authorized for monitoring gamma, x-ray, beta, and neutron radiation. For neutron radiation monitoring with the DT-702/PD, a default energy correction factor provides a conservative dosimetry value and should normally be applied. For situations where refined dosimetry values are needed, specific neutron energy correction factors can be determined as described in section 6-6(1)(b).

(a) The DT-702/PD dosimeter has replaced the DT-648/PD because it has improved capabilities, and can meet more stringent accreditation requirements. The DT-702/PD dosimeter utilizes a new copper doped LiF TLD material, a redesigned holder, and a more robust dose algorithm. It demonstrates: 1) a higher sensitivity with less than 5% signal fade over a year; 2) increased accuracy, precision and reliability in dose determination; 3) greater tissue equivalence, and 4) increased accuracy in photon energy discrimination. The DT-702/PD dosimeter therefore provides for true energy characterization over a wide range that will meet all of the requirements of the ANSI N13.11 standard without any changes to the existing processing infrastructure.

(2) *Initiation*. To initiate personnel dosimetry services, submit a letter request to the Naval Dosimetry Center. The request should state the number of individuals to be monitored, the source(s) and type(s) of radiation to be monitored, the activity's unit identification code (UIC), a desired starting date for dosimetry services, a complete mailing address, an e-mail address and name and telephone number of a point of contact. Activities shall send requests via their chain of command. Upon approval of the request, the Naval Dosimetry Center will forward a package containing the necessary equipment for initiating the program.

(3) *Implementation and Use*. Upon request by an activity and approval by the Naval Dosimetry Center, the following items will be provided to the activity:

- ✓ A set of TLDs-quantity determined per the activity's request
- ✓ Twice the number of card holders as TLDs-one set to wear, and one set to work with when changing out the TLDs
- ✓ Card holder openers
- ✓ Optional identification and security stickers for the card holders
- ✓ Optional card holder clips
- ✓ External warning labels for TLD card shipment containers
- ✓ A shipping list (paper and electronic form)
- ✓ Implementation software on a set of computer disks

(4) *Description of the LiF Thermoluminescent Dosimeter card.*

(a) The DT-702/PD TLD (copper-doped) card consists of four LiF:Mg, Ti,Cu, P TL elements of different thickness and composition mounted between two teflon sheets on an aluminum substrate. The TLD card holder covers each TL chip with a filter providing different radiation absorption thicknesses (similar, but not identical to the holder) to allow evaluation of deep and shallow dose equivalents. Elements 1, 2 and 3 are Li-7, which is sensitive to photon and beta radiation. Element 4 is Li-6, which is sensitive to photon, beta and neutron radiation. The card has a bar code identification label across the face and must be used only in the black card holder, provided specifically for this dosimetry card; no other holder is authorized. The card holder itself has a bar code located on the inside surface of the front cover.

The DT-702/PD card holder is hinged and contains a window to allow verification that a TLD card is inserted. The holder is notched to prevent use of any other TLD card in the DT-702/PD holder. See Figures 1 and 2.

Figure 1. DT-702/PD TLD card holder

View from Outside View from Inside

Figure 2. DT-702/PD TLD and card holder showing bar codes on both the card and the holder

(5) *Factors affecting accuracy*. The LiF TLD is not overly sensitive to environmental extremes, and does not require cold storage. However, to achieve the most accurate results, the following factors must be considered:

(a) LiF TLD cards should be kept clean. Spurious dose readings can result if the card is soiled or chemically stained. Each TLD card shall be carefully inspected upon collection, and soiled cards cleaned prior to their return for processing. Cards may be cleaned locally using a soft sponge made damp with mild detergent and water, and then rinsed with a clean, water dampened sponge. Do not use chemical solvents or cleaning fluids on LiF TLD cards. Do not mark, write, or put tape on either side of the card.

(b) Damaged cards, such as bent, broken, missing components, permanently soiled or stained, should be noted by a comment in the remarks section of the dosimetry report. The Naval Dosimetry Center can repair most types of

damage and accurately evaluate the TLD provided the damage is recognized before the card is processed.

(c) Sunlight and fluorescent light can, after prolonged exposure, induce false TLD readings of up to 20 mrem (0.2 mSv). This is reported to occur if the TLD card is exposed to light for several hours while removed from the holder. Thus, bare LiF TLD cards should be stored in the dark when not in use.

(d) Static electricity or electrical discharge has been reported to have caused spurious dose readings on LiF TLD cards. This occurs only if the bare cards are subject to such treatment while removed from the holder. If it is suspected, include a comment in the remarks section of the dosimetry report.

(e) High ambient temperatures (over 115 degrees F) can cause reduced sensitivity of the LiF TLD and may result in dose evaluations being as much as 25% low. If a LiF TLD is used where the ambient temperature exceeds 115 degrees F on one or more days during the issue period, note in the remarks section of the dosimetry report "TLD# _____ exposed for _____ days to temperatures above 115 degrees F; estimated temperature_____ degrees F".

(f) The integrity of the card holder is critical to ensuring an accurate measurement. If a holder is damaged in a way that compromises its ability to protect the TLD card (for example, if the mylar window is torn), it can allow the TLD card inside to be damaged, exposed to light, or collect dirt. Each TLD holder shall be carefully inspected prior to issue and upon collection. A defective or damaged holder shall not be used. If a holder is discovered upon TLD collection with damage that could have affected its ability to protect the TLD card, it shall be reported in the remarks section of the NAVMED Form 6470/3A, indicating which TLD card number corresponds to the damaged holder, and the nature of the damage.

(g) The accuracy of neutron measurements by the DT-702/PD is dependent upon the area of the body on which the dosimeter is worn. The waist or chest will provide adequate neutron moderation and reflection of thermal neutrons into the neutron-sensitive element. If the dosimeter is worn at other anatomical locations (i.e., the neck, head or extremities), the neutron response will only be an indication of neutron exposure and not a dose of record.

(6) *Card Holder and Opener*.

(a) The DT-702/PD card has a concave cut-out on each of the two long sides of the card and is notched in one corner for proper alignment in the molded card holder. With proper orientation of the card, the holder will snap shut easily. If the holder does not close easily, check for mis-orientation of the front and back of the holder, or for some other obstruction. After snapping the holder shut, verify that the card was oriented correctly by checking that the card serial number can be read upright through the red viewing window on the back of the holder when held with the hinge on the top.

(b) To open the DT-702/PD holder, place the opener in the slot at the end of the holder via the back, with the thumb depressor of the opener oriented toward the opposite end of the holder, and press the opener to open the holder. Do not torque the opener in the slot of the card holder. See Figure 3 for proper opener orientation. Improper orientation will make opening impossible.

Figure 3. DT-702/PD opener properly inserted into the holder for opening.

(7) *Wearing the DT-702/PD*. The holder with the card enclosed should normally be worn on the front of the trunk of the body when the source of radiation is likely to be isotropic or from the front of the wearer. It may be worn on the back of the waist or chest when appropriate. In unique situations as discussed in section 6-3(2), additional DT-702/PD TLDs that are worn in areas other than the waist or chest provide an accurate measure of beta and photon dose, but only an indication of neutron exposure, as noted in section 6-5(5) (g).

Attachment to the body is normally accomplished by one of two methods (shown in Figure 4):

(a) The belt loops on the back of the card holder can be used to place it on a belt; for neutron monitoring, this is the only method authorized;

(b) An attachable strap can be used to attach it to a pocket flap or lapel. Additional TLDs worn in unique situations, as discussed in Section 6-3(2), may be held in place by tape, elastic or cloth bands, clips, or in plastic/cloth pouches, regardless of the method of attachment, the badge holder must be positioned so the front of the holder is facing away from the body.

Figure 4. DT-702/PD TLD properly worn at the waist and chest.

(8) *Issuing TLDs*

(a) TLDs shall be issued (a new issue period begun) as soon as practicable after receipt. Do not mix TLD batches. All TLDs used during an issue period should be from the same batch. Inspect the TLDs upon receipt to ensure the serial numbers match those on the enclosed shipping list, and no damage has occurred in transit. Information required on the dosimetry reports shall be entered according to instructions on the reverse side of the forms or instructions in this manual, whichever is the more current. (Activities using a BUMED approved computer program shall follow the instructions provided in the program.) Special care must be taken to ensure the names of the individuals receiving the dosimeters are properly recorded, and the correct radiation type code and occupational code are assigned (see back of NAVMED Form 6470/3A) to ensure proper processing and dose assignment.

(b) The issue period for the DT-702/PD LiF TLD shall be six to seven weeks (i.e., twice per quarter), except as provided below:

(1) For personnel assigned to fleet ballistic missile submarines, the issue period shall be for the duration of a patrol cycle.

(2) For other afloat activities (i.e., fast-attack submarines, nuclear-powered aircraft carriers, amphibious warfare ships), the standard issue period shall not exceed a maximum of 3 months.

(3) Personnel in the dosimetry program have an ongoing need for monitoring and most are issued a LiF TLD for the entire issue period, to include absences from the command during the issue period (for example, leave). For personnel issued a TLD after the start of the issue period, or who turn in a TLD before the end of the issue period (for example, due to transfer or termination), the issue and collection dates should reflect the actual period of issue. For personnel who are issued a LiF TLD for a particular job of less than the regular issue period, the issue period should be for the duration of the time the TLD is actually issued to the individual for the job. For example, if the individual is issued a TLD on the 11th of the month, and the same TLD is collected from the individual on the 23rd of the same month, the issue period is from the 11th to the 23rd of the month. A LiF TLD collected before the end of the issue period shall not be separated from the rest of the cards in issue; it should not be sent under separate cover from the batch it was shipped in; it should be kept with the rest of the batch until ready for submission to the Naval Dosimetry Center. If an individual is issued a TLD at some other time than the start of the issue period and the individual's jobs will involve exposure for the rest of the period, then the issue period shall be from the time of issue to the end of the period, including periods of leave.

(4) For personnel suspected of having exceeded an exposure limit, their LiF TLD and two control TLDs from the same batch shall be submitted for evaluation as soon as practicable. Submission of the TLDs should be coordinated with the Naval Dosimetry Center to ensure receipt and prompt processing.

(c) The issue period for posted environmental or area dosimeters shall be the same as that used for personnel.

(d) If replacement dosimeters are not available at the end of the normal issue period, the issue period may be extended until new dosimeters are available. However, if an extension of the normal issue period is necessary, the Naval Dosimetry Center shall be notified by typed correspondence (i.e. message, e-mail, letter) to alert the Dosimetry Center to potential shipping and/or TLD exchange problems. A return response will not be sent unless requested. LiF TLDs shall not be kept for greater than 150 days without Naval Dosimetry Center approval.

(9) *Collecting and Submitting TLDs for Processing*

(a) At the end of the issue period, all personnel and posted/area dosimeter TLDs shall be collected, the cards removed from their holders and placed in the same numerical order as they appear on the report form, NAVMED Form 6470/3A. The cards shall be submitted to the Naval Dosimetry Center within five working days after collection unless otherwise approved by BUMED. All dosimeters from the same shipment batch shall be returned together.

(b) When removing the LiF TLD card from its holder, observe any change in orientation from the designed orientation and if the TLD card has been rotated or put in upside down, note the change in orientation in the remarks section of the NAVMED Form 6470/3A. Damage to the TLD card, damage to the holder that affects its ability to protect the TLD card, or any unusual occurrence associated with the TLD card during the issue period shall be recorded in the Remarks section of the NAVMED Form 6470/3A. Handle cards with care; ensure hands are clean and dry. Dirty cards shall be cleaned per paragraph 6-5(5)(a).

(c) TLD cards shall be packed in the shipping container to maintain order. Cards may be secured in the shipping container by filling voids with packing material. Do not wrap the cards or use adhesive tape or rubber bands that contact the cards.

(d) Forward an original dosimetry report, NAVMED Form 6470/3A (see Appendix A for sample) with each submission. Each shipment shall be sent via traceable means, e.g., certified mail. Each shipment of TLDs sent from the Dosimetry Center should contain a printed list of card serial numbers in that shipment; this list should be returned with the shipment when sent to the Dosimetry Center for evaluation. If an entire shipment is being returned to the Dosimetry Center unused, the shipment shall be accompanied with a memorandum indicating the TLDs were unused.

(e) If a DT-702/PD is used for research or other purposes so it received a dose greater than five rem, it shall be segregated from the personnel monitoring TLDs and marked for special processing. This precaution is to preclude high dosed TLDs being mistaken for personnel monitoring dosimeters. In addition, if the dosimeters have been dosed in excess of 100 rads then that should be indicated. Processing DT-702/PD dosimeters dosed in excess of 500 rads requires special adjustments to the processor to prevent damage and loss of glow curve information.

(10) *Control LiF TLDs*. The purpose of submitting control dosimeters with each submission group to be evaluated is to determine the amount of radiation the TLDs receive from background or other sources while they are in transit or being stored. As such, control TLDs should be stored with the unused cards in a low background area, away from any existing man-made radiation sources.

(a) Two control LiF TLD cards, which must be from the same batch as the issued TLDs, shall be included and designated as control cards in each submission for evaluation.

(b) Exposure from control TLDs is subtracted from the personnel/posted dosimeter exposure readings at the Naval Dosimetry Center. The value of the control listed on the exposure report form is raw exposure and neutron dose for control cards does not include neutron energy corrections. The dose listed for personnel/posted/area dosimeters is the net exposure of the card i.e., gross card readings minus the background exposure.

(11) *Storage of LiF TLDs*

(a) When issued personnel dosimeters are not being worn, they should be stored in a low background area, i.e., an area where the dosimeters are not being exposed to manmade radiation sources. Likewise, control and unissued LiF TLD cards shall be stored in an area removed from man-made radiation sources, but not in a shielded container. Unused cards may be used as control cards to improve statistical process control and therefore must be treated the same as control cards.

(b) Do not stockpile batches of TLDs. Maintaining more than one set of TLD cards is not authorized.

(12) *Dosimetry Report Forms*. The form used with the DT-702/PD dosimeter is the Radiation Exposure Report NAVMED Form 6470/3A. The reverse side of the form has detailed instructions on how to prepare the report for submission. After the LiF cards are evaluated, a report will be completed by the Naval Dosimetry Center and returned to the submitting activity. A copy of NAVMED Form 6470/3A is contained in Appendix A.

(13) *Changes to Program*. Changes to the local dosimetry program shall be communicated to the Naval Dosimetry Center by letter or message. Examples of the types of changes that should be communicated are:

(a) Large changes in the number of personnel monitored;

(b) Problems that affect your program;

(c) Temporary or permanent termination of the requirement for dosimetry services;

(d) Address or UIC change.

(14) *Security and Identification Stickers*. These items are for optional use determined by the customer.

(a) After the TLD card is loaded into the black holder, an optional gray sticker stating "USN Do Not Remove" may be placed in the slot at the top of the badge holder to prevent tampering. The tape cannot be removed without destroying the tape, indicating the holder may have been opened. The wearer shall be instructed not to attempt to open the holder, as the card holder may be damaged or the card misoriented.

(b) The optional identification sticker may be placed only on the flat portion of the front of the black card holder. The use of different color stickers per issue period can assist in collection and distribution of the dosimeters. The identification label must never be placed directly onto the LiF card. Adhesive residue will alter the signal produced by the LiF chips when heated, producing an erroneous reading. In addition, do not write any information, i.e., the wearer's name, on the LiF card.

(c) If the silver mylar window on the DT-702/PD badge holder is damaged, then the holder must be sent back to the Dosimetry Center for replacement since it is sonically welded into place with a plastic set ring. Damage to the window does not require a subsequent dose estimate to be performed.

(15) *Suspension of Dosimetry Program*. Commands may temporarily suspend personnel dosimetry during upkeep or overhaul periods as deemed operationally appropriate. If the Naval Dosimetry Center provides the dosimetry devices, indicate the projected date of program suspension to the Naval Dosimetry Center by letter. Reactivation of the personnel dosimetry program will require written communication with the Naval Dosimetry Center.

(16) *Termination of Dosimetry Programs*. To permanently terminate an existing personnel dosimetry program, submit a letter to the Naval Dosimetry Center stating the command name, UIC, and projected termination date. With the submission of the final issue of personnel dosimetry devices, include all unused/recovered TLDs, TLD holders, holder clips, and openers. Upon receipt of the final exposure information, forward a Situational Report of Occupational Exposure, NAVMED 6470/1, with remarks in block 17 indicating the program has been discontinued.

(17) *Decommissioned Vessels and Commands*. Disposition of personnel radiation exposure records including annual and situational reports, exposure investigations, worksheets, charts, calibration results and statistical summaries will be as prescribed by SECNAVINST 5212.5 series.

6-6. Environmental and Area Monitoring

(1) The DT-702/PD can be used as a photon/beta monitor or a gamma/neutron monitor.

(a) The DT-702/PD card, placed in its black holder can be used as a photon/beta posted dosimeter. No special mounting or phantom is required; however, the device shall be oriented so the front of the card holder faces the radiation source if known. If the direction of the radiation source is unknown or isotropic, the orientation of the posted TLD is not important. The term "posted" is used with this type of monitoring.

(b) The DT-702/PD card placed in a polyethylene cylinder, which is essentially the same size and internal design as an AN/PDR-70, constitutes a gamma/neutron area monitor to monitor gamma and neutron radiation. This area monitor, designated as the Neutron Area Monitor (NAM) is available in two forms; a single drawer version (Figure 5) and a five drawer version (Figure 6). Both versions are totally encased in an aluminum box for mounting and protection. The polyethylene cylinder with a center drawer that holds two cards, constitutes the single drawer version (Figure 5). It may be used in areas where the neutron energy spectrum is not known since it is relatively energy independent.

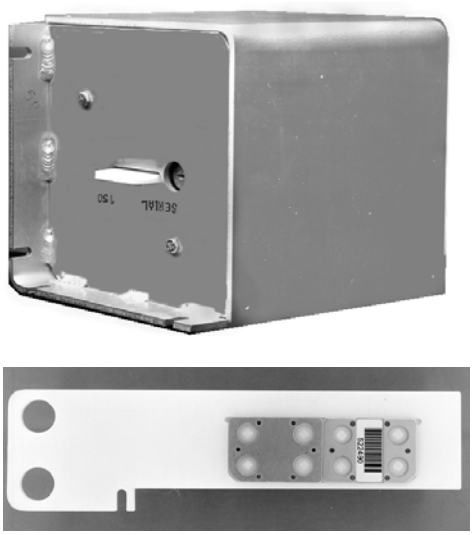

Figure 5. Single drawer version of the Neutron Area Monitor (NAM) (top) with plastic drawer showing the placement of 2 TLD cards (bottom)

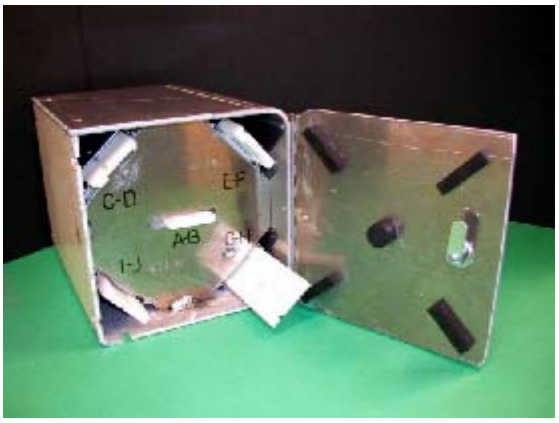

Figure 6. Five drawer version of the Neutron Area Monitor (NAM) showing the placement of each drawer. Two TLD cards fit into each drawer only one way. Each drawer is keyed to fit in only one location.

The five drawer version is the same basic design as the single drawer version with the exception of having four additional drawers located on the perimeter. Each NAM is uniquely identified with a three digit serialization number. Each of the drawers holds two TLD cards, the positions of which are identified with a capital letter. The two cards in the middle drawer are positions A and B. It doesn't matter which is A or B for calculational purposes as both are treated equally. Similarly, each perimeter drawer on the NAM is labeled with two unique letters (C/D, E/F, G/H, I/J) in order to record the placement of the cards located there. As with the middle drawer, the letter pairs on each perimeter drawer are interchangeable as they are treated equally in the calculations. For example, position C and D are interchangeable, as are E and F, etc. There are a total of 10 card positions (2 in the middle and two in each of the four corners) in the NAM. Instructions for entering NAM cards on the NAVMED 6470/3A are located on the back of the form.

The additional perimeter TLD cards in the 5 drawer NAM allows for the calculation of a Neutron Energy Correction Factor (NECF) for the DT-702/PD dosimeters. DT 702 TLDs are neutron albedo devices, meaning that they measure the thermal neutron reflection from the body. Neutron albedo measuring devices require that a NECF be

applied to the measurement to account for the incident neutron energy spectrum. The NECF may also be calculated by using a AN/PDR-70 RADIAC with a Naval Dosimetry Center protocol. All protocols used to calculate NECFs must be approved by BUMED. Questions regarding neutron measurements, NECFs, or protocols should be referred to the Naval Dosimetry Center.

The NAM is the only device authorized for neutron area monitoring. The area monitor should be mounted, either by bolting or gluing, so one of the four larger surfaces faces the neutron source, and the center drawer is in the horizontal plane. The center drawer is manually removed when unlocked and two LiF TLD cards are inserted so the notched corners of the cards align with the positioning guide in the drawer. When correctly inserted, one card will have the I.D. number side down, and the other the I.D. number side up with the six digit serial number visible (see Figure 5). The purpose of this design is to bring the neutron sensitive elements on each card as close together as possible for better consistency between those measurements. The perimeter drawers in the NAM work in a similar fashion. After positioning the cards, slowly slide the drawer into the phantom, close and lock. The term "area monitor" is to be used only with the NAM. Activities required to perform neutron area monitoring may request the NAM from the Naval Dosimetry Center.

6-7. Extremity Monitoring

(1) A limited number of personnel, particularly those in nuclear medicine, radiation therapy, research and some industrial applications are required to wear finger ring dosimetry. Typically, individuals working with more than 1 mCi of an unshielded (with respect to their hands) source of high energy beta (e.g. P-32), photon emitter (e.g. I-125), or x-ray diffraction unit wear finger rings. To assure appropriate radiation protection practices are followed and to evaluate exposure to extremities, the Naval Dosimetry Center provides and evaluates the DXTRAD finger ring dosimeter (Figure 7).

(2) Finger ring service may be obtained upon request to the Naval Dosimetry Center, stating the requirement, number of personnel to be monitored, location of the dosimeter on the individual, radioactive materials being handled, and other pertinent information. Instructions for handling and use of the DXTRAD are provided to the customer upon approval of program implementation by the Naval Dosimetry Center. The NAVMED Form 6470/3B (Appendix A) is used when submitting DXTRAD dosimeters for evaluation. DXTRAD finger ring dosimeters are shipped to the requestor ready for use. The dosimeter is shipped with a LiF TL element already

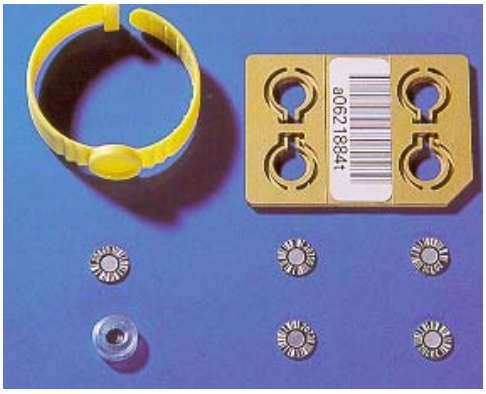

Figure 7. DXTRAD finger ring dosimeter (left) and element processing holder (right) used by the Naval Dosimetry Center

installed requiring no adjustment. The DXTRAD should be returned to the Naval Dosimetry Center in the same material condition (unopened) as received.

6-8. Accident Dosimeters

(1) The DT-518/PD accident dosimeter (Figures 8 and 9) is a passive dosimeter which is mounted on secondary shielding surrounding naval nuclear reactor plants. The end cap of the personnel dosimeter, DT-526/PD is based on the DT-518/PD design (Figure 10).

(a) The DT-518/PD contains indium discs, sulfur discs, and thermoluminescent powder. The indium discs may be used for field evaluation of the neutron dose significance. The sulfur discs (for definitive neutron dose determination; 10-50,000 rad) and the thermoluminescent powder (for gamma dose determination; 1-10,000 rad) are for evaluation by the Naval Dosimetry Center. Similar sulfur and indium discs are also contained in the end cap of the DT-526/PD.

(2) In the event of a suspected high dose (accident dose) to an individual wearing the DT-526/PD, refer to BUMEDINST 6470.10 (series), Enclosure 5, "Neutron Exposure."

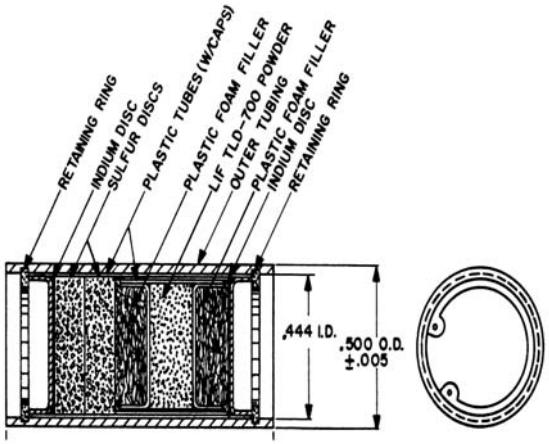

Figure 8. Illustration of the DT-518/PD accident dosimeter with retaining rings and detector capsule

Figure 9. Photograph of the DT-518/PD accident dosimeter. The scale shown is in inches.

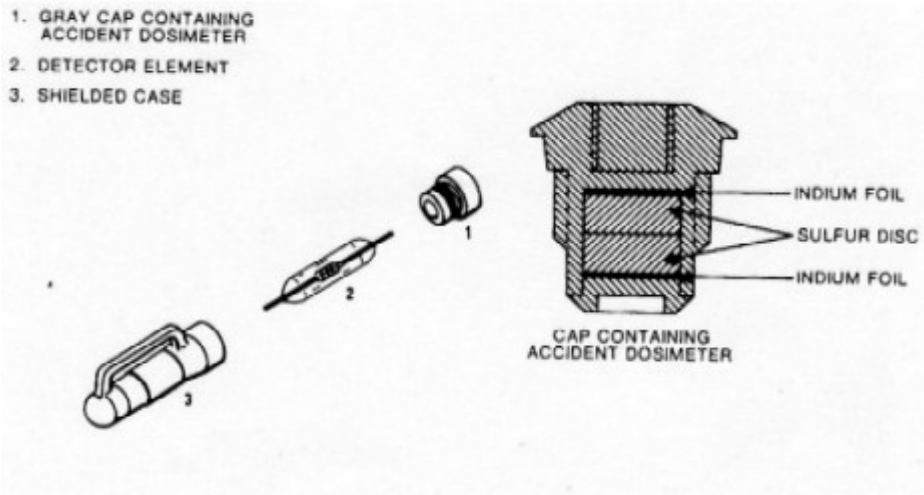

Figure 10. End cap of DT-526/PD

(3) In the event of a suspected high dose (accident dose) to the posted DT-518/PD:

(a) Record the time at which the accident is believed to have occurred. Promptly obtain a properly functioning gamma-ray sensitive RADIAC (e.g. an

AN/PDR-27 or IM-265/PDQ multi-function radiac) and in the case of the AN/PDR-27 select the most sensitive (0.5 mR/h) scale. Read and record the meter indication as the background reading.

(b) Place the accident dosimeter against and parallel to the most sensitive gamma probe (normally largest in size). The beta shield should be closed (if applicable). Observe the meter reading as the accident dosimeter is moved along the length of the probe. Record the highest reading observed as the gross reading. Record the time at which the reading was obtained.

(c) Subtract the background reading from the gross reading. This difference is the net reading (nr). An estimated neutron accident dose (± 25%) may be calculated for the point where the accident dosimeter was located at the moment of the accident as follows:

Neutron Accident Dose (rad) = nr (mR/h) x 8 x (F)

where the Correction Factor (F) is obtained from Figure 11 using the difference between the time of reading and the presumed time of the accident as the time of screening (hours after exposure).

(d) Finally, the accident dosimeter shall be sent to the Naval Dosimetry Center for definitive evaluation.

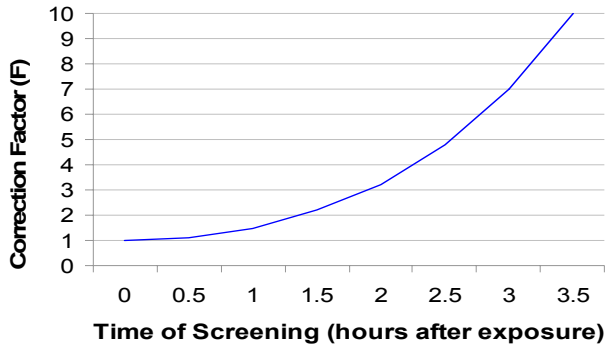

Figure 11. Correction Factor (F) for field screening of Navy accident dosimeter indium discs

6-9. Battlefield Dosimeters

(1) *The DT-60 Navy battlefield dosimeter* (Figure 12).

(a) A passive dosimeter that uses a silver phosphate glass that darkens with exposure to high-energy gamma and thermal neutron irradiation. The dosimeter is housed in a black plastic case that is sealed with a rubber gasket

(b) The DT-60 is read in the CP-95/PD Reader

(1) The CP-95/PD runs on 110V, 60 Hz AC power.

(2) This reader is calibrated for Co-60 gamma exposure.

(3) The CP-95 Reader has two scales that readout in roentgen (R) or rad (0-200 and 0-600).

(c) The lower limit of detection for this detector is 10 rad.

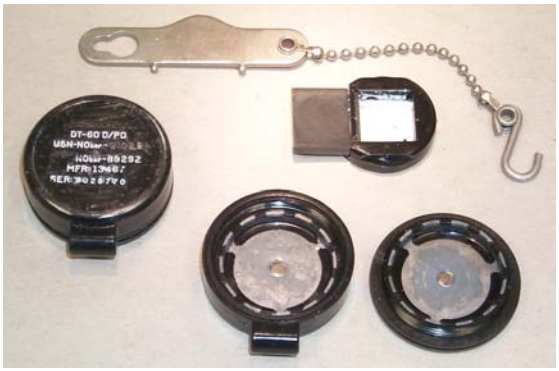

Figure 12. DT-60 battlefield dosimeter. (Top: Opener, Left: Unopened, Right: Disassembled).

(2) *The DT-236 Marine Corps battlefield dosimeter* (Figure 13)

(a) Designed to measure short duration, high intensity neutron and prompt gamma radiation.

(b) Uses a wide based silicon junction diode to measure neutron radiation and a silver activated phosphate glass to measure gamma radiation.

(c) The elements are encased in a tamper resistant locket worn on the wrist.

(d) The DT-236 can be used over a wide temperature range (-32^{o} C to +52^{o} C) and withstands all military environmental requirements e.g. shock, vibration, nuclear hardness and decontamination.

(e) The DT-236 is read with the AN/PDR-75 RADIAC set powered by a 24 Volt DC source and uses a single digital readout to display the combined gamma and neutron dose ranging from 0 to 1000 rad. The reader takes non-destructive readings as often as desired. The lower limit of detection for these devices is 5 rad neutron and 5 rad gamma.

Figure 13. Marine Corps DT-236 battlefield dosimeter; (Top: On wristband, Bottom: Opened up).